Advanced Component Technology Program

IMPRESS Lidar: Integrated Micro-Photonics for Remote Earth Science Sensing Lidar

Completed Technology Project (2018 - 2020)

Project Introduction

This investigation will demonstrate ultra-low size, weight, and power (SWaP) Lidar photonic integrated circuits (PICs) for Earth science sensing applications for measuring atmospheric constituents such as carbon dioxide (CO2). The extreme reduction in SWaP will enable significantly more science measurements at lower cost. This technology development is applicable to current and planned applications like lab demonstrations, heavy-lift aircraft (e.g. DC8) measurements, and satellite missions such as ASCENDS, but it is particularly enabling for limited-resource platforms like cubesats and unmanned aircraft (e.g. Ikhana). The integrated Lidar PIC will enable spectroscopic measurements of the Earth's atmosphere with increased sensitivity while significantly reducing SWaP. It will enable near infrared (NIR) multi-wavelength analysis (e.g. CO2 and greenhouse gas monitoring) with the same integrated device. The focus of this work will be to realize a fully functional system on a chip for Earth science measurements using photonic integration technology. PICs have been highly developed for the telecommunications industry; however, these PICs do not meet the needs for scientific Lidar applications. We will leverage the significant investment from the telecommunications industry and develop PICs customized for Earth science applications. The PICs will include components such as fast tuning optical sources, photodiodes, and passive waveguides. PICs will be closely integrated with electronic integrated circuits (EICs) to form sophisticated integrated optical phase-locked loop (PLL) circuits for dynamically switching and locking a seed laser module across the gas absorption line. The PICs could eventually be qualified for space, thus setting a path for insertion into future NASA missions. The proposed technology is modular and can be transferred to other wavelengths for measurements of other species. Our objectives are to (1) significantly lower the cost and SWaP of the Lidar transmitter, (2) enable missions for multiple species not possible with prior state of the art, (3) scan multiple programmable wavelength points, and (4) improve transmitter reliability and ruggedness. Although we propose laser spectroscopy as a pathfinder demonstration, investment in this technology will have significant reach into many additional NASA science measurements that are enabled by reductions in SWaP, cost and complexity and improvements in performance. The team comprises the University of California Santa Barbara (UCSB) and members of the Science and Engineering Directorates at NASA Goddard Space Flight Center (GSFC). These groups are experts in integrated photonics and Lidar, respectively. UCSB has pioneered PICs based on a number of materials platforms, and is also the West Coast Hub of the American Institute for Manufacturing Integrated Photonics (AIM Photonics), a federally funded Institute for Manufacturing Innovation. UCSB is currently working on two NASA grants in close collaboration with the Lasers and Electro-Optics Branch at NASA GSFC: The Early Career Faculty Space Technology Research Grant on Low SWaP Lasers for Deep Space Communications and the Early Stage Innovations Award on Integrated Photonics for Low-Earth Orbit Space Optical Communications. The group at GSFC has been working on the ASCENDS

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of California-Santa Barbara (UCSB)

Responsible Program:

Advanced Component Technology Program

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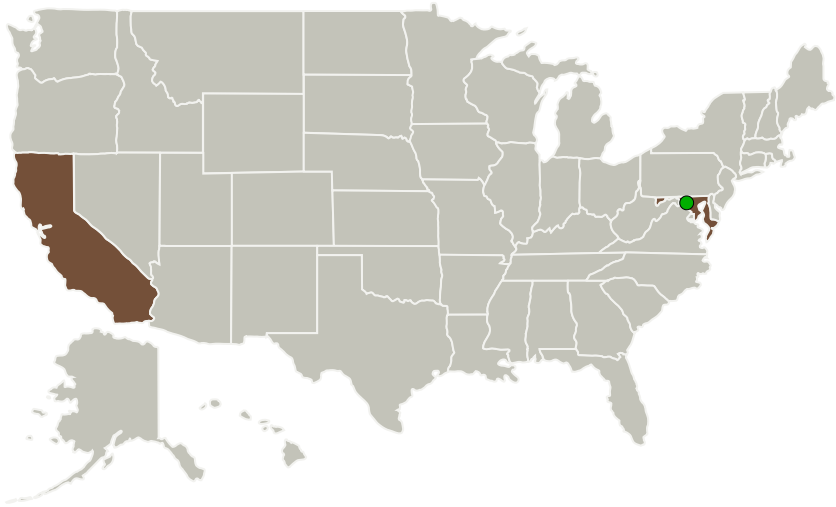
Mission and related technology development for many years and has direct knowledge of the science needs and the instrument performance requirements. The combination of device, PIC, integrated optical PLL, and electronic-photonic subsystem expertise from UCSB, with the Lidar, laser instrument, Earth science, detection, and remote sensing expertise from NASA GSFC puts our team in a strong position to achieve the objectives of this program. The period of performance is 01/01/2018-12/31/2020. The entry TRL is 1-2 and the planned exit is 3-4.

Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Pamela S Millar

Program Manager:

Amber E Emory

Principal Investigator:

Jonathan Klamkin

Co-Investigators:

Karla Burris
Stephan R Kawa
Jeffrey R Chen
Mark A Stephen
Larry A Coldren

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers

Target Destination

Earth

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Organizations Performing Work	Role	Type	Location
University of California-Santa Barbara(UCSB)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI), Hispanic Serving Institutions (HSI)	Santa Barbara, California
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
Office of Research	Supporting Organization	Industry	Santa Barbara, California

Primary U.S. Work Locations	
California	Maryland